Catching Math Learning Problems Early

In this article in *Exceptional Children*, Russell Gersten, Rebecca Newman-Gonchar, and Kelly Haymond (Instructional Research Group), Ben Clarke (University of Oregon), Nancy Jordan (University of Delaware), and Chuck Wilkins (Edvance Research) report on their search for efficient, sensitive, and specific mathematics screening instruments for early primary students. Why is this important? Because kindergarten children who are struggling with math have a very high probability of failing math in later grades – and early intervention can make a difference.

The key is using a screening instrument that pinpoints the children who will have difficulty later if they don't get help. "Just as the persistence of reading disabilities stimulated widespread investment in early intervention and screening in reading," say the authors, "we hope that the concurrent findings for the persistence of mathematics difficulties will incite similar leaps for identifying measures to screen students likely to experience difficulties in mathematics."

What are the screening priorities in kindergarten and first grade? Researchers have found that children with good number sense appear to develop a mental number line on which they can represent and manipulate numerical quantities. But there's more to number sense than that, say the authors. Children who have good number sense understand the meaning of numbers, can make simple magnitude comparisons, develop strategies for solving number problems, and invent procedures for conducting numerical operations. Gersten, Clarke, Jordan, Newman-Gonchar, Haymond, and Wilkins prefer the term *number proficiencies* to describe these understandings and skills.

The authors' search for good screening instruments started with 48 studies and zoomed in on 16 that met their criteria for accurately and quickly predicting mathematical difficulty in later grades (they rejected instruments that took more than a few minutes per student as impractical). Here are the areas measured by the best instruments, each correlating quite well with later math success:

- *Magnitude comparison* – For example, understanding that 11 is a bit bigger than 9 and 18 is a lot bigger than 9. The predictive validity was .62.
- *Strategic counting* – Understanding how to count efficiently and use counting strategies – for example, being able to identify a missing number (between 1 and 10 in kindergarten and 1 and 20 in first grade) and "count on" (if asked "what is 9 more than 2", seeing that it's quicker to reverse the problem and count on from 9). The predictive validity was .37 for kindergarten students and .68 for first graders.

- *Word problems involving simple addition and subtraction* – Surprisingly, young children find it easier to solve a word problem (How many sheep are left if you start with 9 and lose 2?) than a number sentence (9 – 2 = 7). The predictive validity was .51.
- *Retrieval of basic arithmetic facts* – The ability to efficiently store and retrieve abstract information (semantic memory) appears to be crucial for students to succeed in mathematics. Weakness in this area may be an early sign of a learning disability or it may stem from a lack of number sense: "It is difficult for children to become automatic with addition and subtraction number combinations when they do not have a good sense of relations between and among numbers and operations," say the authors.

The predictive validity was .55 for first graders and .59 for second graders. Gersten, Clarke, Jordan, Newman-Gonchar, Haymond, and Wilkins also examined the Number Knowledge Test, which takes 10-15 minutes per child and has a predictive validity coefficient of .73 – somewhat higher than the individual screening measures listed above.

The authors then explore other measures that seem to be correlated to later proficiency in mathematics:

• *Working memory* – This can be assessed by asking students to repeat a set of numbers read to them (9, 4, 17, 8) in precisely the reverse order (8, 17, 4, 9). Working memory is important in mathematics because students need to be able to juggle several bits of abstract information – basic facts, positions of numbers on a mental line, computational procedures, etc. Measuring working memory is a less effective screening tool than those described above, but it can add precision.

• *Student engagement and attentiveness* – This had a .35 correlation with future mathematics achievement, say the authors. "This effect was striking because the impact of student engagement was greater than time spent on instruction and the effect showed the greatest impact for the lowest achieving students," they write. "This finding suggests that interventions for students with problems in mathematics might seriously consider adding a component that promotes attentiveness to academic tasks and activities."

Finally, the authors address classification accuracy – the sensitivity and specificity of various tools. The two things early math screening should avoid are: (a) missing students who truly need and will benefit from extra help (false negatives), and (b) identifying students who will succeed in math without extra help (false positives). "A measure with perfect sensitivity ensures that all students who require intervention receive extra support," say the authors. "A measure with perfect specificity ensures that schools do not spend resources on students who do not need extra support. However, measurement in education, medicine, psychology, and most human endeavors is far from perfect and consists of a series of compromises and balances… Here we face a bit of a paradox. The more we increase sensitivity, the more we try to ensure that we do not miss any students who might need intervention, but in doing so the more we decrease specificity."

The key question is where to set the cut scores. "Determining risk status is as much an art as a science," say the authors. Literacy educators are learning from using Response to Intervention (RTI) that casting too broad a net results in wasting valuable resources and misclassifying students – but nobody wants to miss students who are truly in need. The authors believe the introduction of Common Core State Standards and new assessment technology will focus and speed up the screening process.

The authors conclude by saying that "the collection of screening data in and of itself does not change student outcomes. Any advances that schools make in screening students in mathematics must occur alongside efforts to improve instructional practices and to develop effective interventions."

"Universal Screening in Mathematics for the Primary Grades: Beginnings of a Research Base" by Russell Gersten, Ben Clarke, Nancy Jordan, Rebecca Newman-Gonchar, Kelly Haymond, and Chuck Wilkins in *Exceptional Children*, Summer 2012 (Vol. 78, #4, p. 423-445),
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